

Center for Arms Control, Energy and Environmental Studies at MIPT

False alarm, nuclear danger

The radar and satellite networks meant to warn Russia of the imminence of a missile attack are breaking down, heightening the risk of accidental nuclear war

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Early in the morning of 9 November 1979, missile crews working deep under the prairie grass of the American Great Plains received warning that a massive nuclear strike from the Soviet Union was on its way. This was no drill. As the crews strapped themselves into their combat chairs, they mentally prepared to do the unthinkable: launch their ballistic missiles in an existential act of retaliation--before being destroyed by the hundreds of megatons of nuclear explosives they believed would be arriving within minutes.

It is now known, of course, that no missile attack was under way. A training tape that simulated all the signals of a massive Soviet first strike had mistakenly been loaded into a computer at the U.S. Strategic Air Command's Cheyenne Mountain control center in Colorado. The mistake was discovered only when U.S. leaders viewed the raw data from U.S. early-warning satellites--part of the standard threat assessment procedures--before deciding to launch a massive nuclear counter-strike. None of the satellites showed any missile launches--and accidental global nuclear war was averted.

Those satellites, known as Defense Support Program (DSP) satellites, can detect the infrared energy radiated from the hot exhaust of a missile's rocket engine launched from anywhere on the earth's surface. DSP satellites reportedly detected all the Iraqi Scud missiles launched during the Persian Gulf War, which also marked the first time the general public became aware of their existence. Though designed to provide an early-warning alert of missile launches on the other side of the earth, their most important function to date has been to assure policymakers that missiles have not, in fact, been launched. *no other reports*

The 1979 incident was not the only false alarm to nearly trigger nuclear war. Shortly after dawn on 25 January 1995, Russian radars detected a rocket launched from an island off the northwest coast of Norway. Because of the limited resolution of the radars, they could determine only that the altitude and speed of the rocket looked like those of a U.S. Trident nuclear missile. Also, although the observed rocket was heading away from Russia, it was on a trajectory that could be used to blind Russian radars and prevent them from detecting an attack from U.S. land-based Minuteman or MX missiles or submarine-based Tridents. Official details of the event have never been released, but most probably, the rocket set off automated warning alarms at the radar sites, which then notified military commanders in

Moscow and elsewhere.

What happened next throughout the Russian command structure is not known, except that then-President Boris Yeltsin was directly involved in the assessment of the warning alarms and the decision not to launch a nuclear retaliation against the West.

Some Western analysts worry that this incident represented a possible failure of Russia's command-and-control system. Russian experts, understandably irritated by alarmist statements in the West that suggest Russian incompetence, have countered that this case proved that their system works, even under a grave threat.

Whatever the truth may be, an analysis of the state of Russia's early-warning satellites at that time indicates that the country's leaders had reliable information that no nuclear attack was under way from land-based Minuteman or MX missiles. But they were unable to determine reliably whether they were under attack from the more capable U.S. nuclear Trident forces in the Atlantic and Pacific--which means that the warning system in 1995 was far from adequate. The fact that Russia did not mistakenly launch a counterattack on the United States at that time hardly guarantees that when future warning system accidents occur, they will lead to the same nondisastrous outcome.

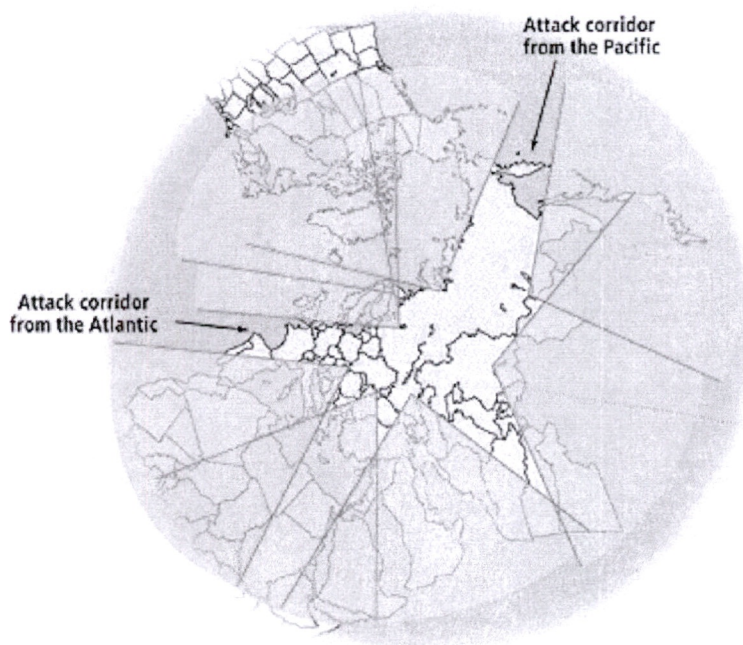


Fig.1. Russia's existing ground-based early-warning radar network, intended to detect incoming missiles, provides incomplete coverage [yellow]. Most of the radars are positioned along the country's periphery, with a few scattered in neighboring countries. From corridors on both the north Atlantic and the Pacific, submarine-based Trident ballistic missiles could fly, undetected, to attack Moscow and Russian missile fields.

designed to warn of nuclear attack from the Atlantic. Plus, there is still an unmonitored corridor of attack from the Pacific. The result is that crucial gaps are evident in Russia's early-warning radar fence [Fig. 1].

What's more, the satellite constellation that in 1995 provided the country's leaders with

Indeed, because of the prolonged effects of Russia's floundering economy, if a similar incident occurred today, Russian leaders would have far less information than they had in 1995.

Currently, Russia is totally blind to a Trident attack from the Atlantic and Pacific, and, for all practical purposes, it is equally blind to a Minuteman or MX attack from the continental United States. With the breakup of the Soviet Union, Russia lost an important radar station in Latvia that was

reassurance that a Minuteman or MX attack was not under way has since suffered from the consequences of both mechanical failures in space and economic failure on the ground. The constellation can perform its early-warning mission only if each satellite is maintained in highly specialized elliptical orbits. Each orbit is fixed relative to the others so that the satellites will pass in sequence high over northern Europe, from which they can each in turn see the space above U.S. missile fields.

Now, however, most of the satellites have failed, or reached the end of their lives, and are drifting out of control. This has resulted in the development of large gaps in coverage during any given 24-hour period. In fact, the U.S. Congressional Budget Office, a federal body that provides Congress with analyses needed to make economic and budget decisions, has estimated that these satellites can work no more than 17 hours of each day, and possibly much less.

As for the newest generation of Russian satellites, designed to warn against submarine missile attack, the system is still inoperable. At present, only one Russian geostationary early-warning satellite, Cosmos 2224, is working, and that was launched in 1992. Given the limited capabilities of these satellites today, and the gaping holes in the ground-based early-warning radar system, it is obvious that the Russians cannot use these systems to reassure themselves that they are not under attack.

These shortfalls in the early-warning system and the faltering political relationship between the United States and Russia increase the chances that an unforeseen set of events will trigger a massive coordinated launch of the latter's nuclear forces. If such an event were to occur, in addition to massive strikes against the United States, it is almost certain that nuclear warheads would fall on other North Atlantic Treaty Organization allies, as well as on other countries that pose a threat to Russia. While various recommendations have been put forward to improve the country's early-warning capabilities, to date little has been done.

Spotting the dangers

Obviously, a deteriorating Russian command-and-control system that cannot distinguish between a benign event and a real attack poses a worldwide threat. Far less obvious is what problems really exist and how they might be solved. Some Russians have openly discussed the issues raised by the potential for accidents in both sides' early-warning systems. But others deny to this day the occurrence of any false alarms--despite first-hand accounts, published in both Russia and the West, of a serious Russian false alarm amid the Cold War tensions of 1983 [see "Colonel Petrov's good judgment"], as well as the post-Cold War incident in 1995.

Fortunately, the physical processes used to detect missiles in flight, the celestial mechanics that govern satellite orbits, and publicly available information released over the years by the U.S. Department of Defense make it possible to construct a fairly complete picture of both sides' early-warning capabilities. The results of such analyses can help in understanding, even without access to classified Russian or U.S. information, what can be done to reduce the danger of nuclear war from accidents that could cause false alerts.

The 1995 incident started harmlessly enough. Shortly before sunrise, NASA, in collaboration with Norwegian scientists, launched a four-stage Black Brant XII rocket to

study the Northern Lights from an island off the coast of Norway.

The launch was no rarity. Andoya Island is the site of a sounding rocket launch facility, from which many scientific experiments have been fired. But the Black Brant XII had a different configuration from that of other rockets typically launched from Andoya, one that, to the low-resolution Russian early-warning radars, made it indistinguishable from a Trident missile in powered flight.

The coincidences that led the Black Brant to be mistaken for a Trident are uncanny, and should be taken as a sobering warning that accidents in these early-warning systems can and will happen again.

The rocket's first and second stages were discarded at a low altitude, never rising to a height where they could be seen by the radar. The third-stage motor also burned out below the radar horizon, but was then carried over the horizon by its momentum. At that point, it was trailing the Black Brant at a speed and distance similar to those between a Trident and its discarded first stage. As the Black Brant's fourth stage rose higher over the radar horizon, its velocity and altitude resembled those of a Trident during its second-stage powered flight. Add to these circumstances the Black Brant's ejection of its nosecone at an altitude and speed similar to those of a Trident. That event led to yet another radar signature tending to confirm that the unknown rocket was a Trident [Fig. 2]. It is a near certainty that the computers on Russia's early-warning radars were programmed to issue an alarm when these signatures were observed in the radar data.

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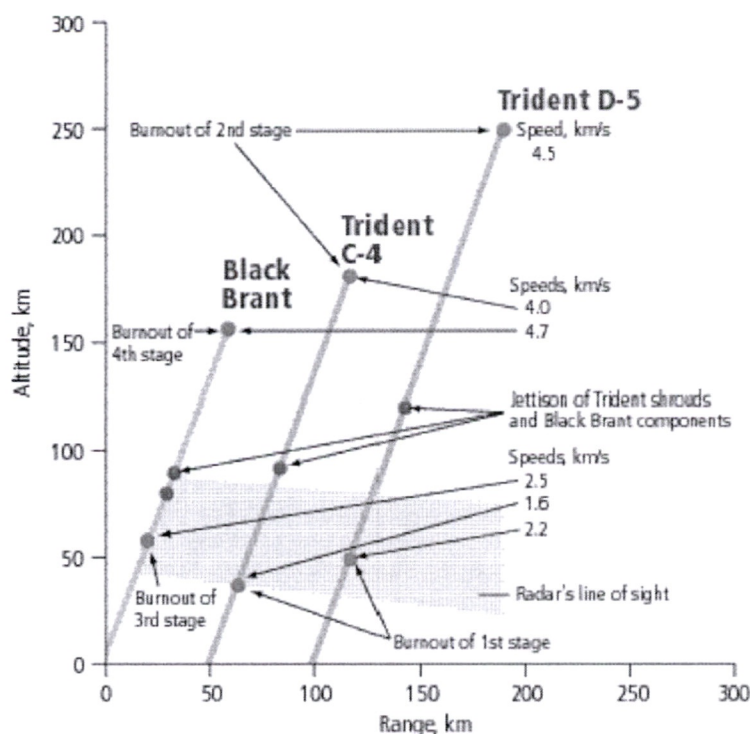


Fig.2. The flight trajectory for a Black Brant XII sounding rocket is shown beside those of a Trident C-4 and Trident D-5. The Black Brant's fourth stage burns out at about the same altitude as the second stages for the submarine-launched ballistic missiles. All three types of missile eject their nosecones and some other components at similar altitudes. The yellow band indicates how the three rocket types would have looked to Russian early-warning radars.

Of course, the coincidences do not fully explain why a single Trident launch--one that was heading away from Russia--would generate a false alert. But the trouble was compounded because, as the NASA radar track of the Black Brant showed, its flight took it directly across the path an intercontinental ballistic missile (ICBM) would take from the main U.S. Minuteman III missile fields to Moscow. In that trajectory, the rocket might have been a multiple-warhead Trident intended to create a pattern of nuclear explosions at high altitudes

that would have blinded the radar.

Once blinded, Russian ground-based radars could not have determined the size of a Minuteman or MX missile attack from the continental United States, or a Trident attack from the North Atlantic. Nor could Russian leaders tell if Tridents were on their way from the Pacific, because they had neither a radar station or satellites that could warn them of an attack from this direction.

If a Trident attack were to come from the Atlantic, Moscow could be destroyed in less than 10 minutes after the initial radar detection, provided that no blinding precursor attack had been attempted. Within minutes of that strike, most Russian strategic ICBM fields would also come under attack. If a Trident attack were to come instead from the Pacific, Moscow could be destroyed with zero warning time.

Given that the information available to Russian leaders was so limited, and that this event was as threatening as it appears to have been, why did Russia not launch a retaliatory strike? Western analysts believe that Russian leaders almost certainly knew there was no massive launch of U.S. ICBMs because their early-warning satellites were observing those missile fields and could see that no missiles were in flight. Had there been a Minuteman or MX launch, the satellites would have warned the Russian Strategic Command minutes after it was fired and tens of minutes before it appeared over the horizons of Russia's ground-based radars.

? In effect, the appearance of a developing U.S. precursor attack designed to blind Russia against Minuteman and MX launches would have puzzled even the coldest Cold Warrior. These inconsistencies, and Russia's ability to determine that U.S. ICBMs had not been launched, must have led to the conclusion that the Black Brant XII was probably not the leading edge of a coordinated nuclear attack. Even so, the lack of information about Trident may explain why it was later reported that Russian leaders tracked the Black Brant's trajectory for roughly 10 minutes—until it was near its apogee--before ending the alert.

Russia's warning satellites

At the time of the 1995 incident, Russia had a full complement of early-warning Oko satellites as well as several Prognost satellites in geostationary orbit.

The nine Oko (Russian for "eye") satellites are placed in highly elliptical orbits with 12-hour periods that take them from a high point of roughly 32 000 km above the earth to a low of 1200 km. Unique to such orbits is their positioning around the earth's circumference. Once every 24 hours, each Oko reaches its highest point, or apogee, over northern Europe, where it has a grazing view of all the missile fields in the continental United States.

Petrov That vantage point is important because such a grazing view avoids the bright infrared background from sunlight reflected off clouds and the earth's surface that can cause false alarms. The reduction in false alarms is achieved in two ways. First, most of a missile's powered flight is seen projected against the black background of space, where the infrared light given off by the hot gases in the missile's plume can be easily distinguished from the few astronomical objects in the background.

Second, the satellite's infrared detector can be fitted with a filter that lets only a very narrow band of the spectrum pass through it. The authors believe the wavelength bands used by these satellites have been chosen to correspond either with the shortwave infrared emission bands of water and carbon dioxide, $2.7\ \mu\text{m}$, or with the longer emission band of carbon dioxide, $4.3\ \mu\text{m}$. Since carbon dioxide and water are the main combustion products of all U.S. missiles, the hot exhaust of these weapons will radiate most strongly within the emission bands of these molecules. Also, as the earth's atmosphere is quite cold and contains both carbon dioxide and water, it tends to absorb, but not emit, most of the sunlight at these infrared wavelengths, so that the earth looks relatively dark when viewed at these wavelengths. The net result is a stronger signal from the missile plume, and a weaker one from reflected sunlight.

Viewing missile fields near the edge of the earth results in these unwanted sun reflections passing through long paths of the lower absorbing atmosphere. Of course, light from the missile also passes through the same long atmospheric paths when viewed from this geometry--concealing the missile until it rises out of the lower atmosphere. Since the absorption properties of the atmosphere vary strongly with wavelength, the $2.7\text{-}\mu\text{m}$ wavelength signal from a missile plume will not be seen until it has reached an altitude of 10-15 km and the $4.3\text{-}\mu\text{m}$ signal will not be seen until it is at 30-40 km. These choices of infrared wavelength trade launch detection during the first minute or so of a missile's flight for fewer false alarms.

Even with this extremely clever scheme for detecting missile launches, the success of a grazing geometry is not guaranteed. At least in part, the potential for false alarms may be why the Soviet Union implemented a second fleet of early-warning satellites with geostationary orbits [see "Inside the U.S. and Russian early-warning satellites"]. Two types of satellites, viewing the continental United States from different space locations, are much less likely to simultaneously experience false alarms from reflected sunlight.

Another, and perhaps more important, reason for Russia's deploying a new generation of warning satellites capable of viewing the vast wastes of the Atlantic and Pacific oceans was the U.S. introduction in 1989 of the submarine-based Trident II missile. The deployment of the Trident IIs gave the United States sea-based missiles that were as accurate as, and carried higher-yield warheads than, the land-based MX. These weapons created the theoretical capability that the United States could destroy almost all of Russia's land-based nuclear missiles if they could be caught before they were launched.

A global perspective

Since about 1970, the United States has launched 17 or 18 Defense Support Program satellites. For most of the DSP's history, three satellites in geostationary orbit have been used to perform the mission of viewing almost all of the earth's surface at once. Currently, though, five are active. The two extra ones are being used to observe areas of special concern, making it possible to get higher-accuracy launch trajectory data relative to what can be achieved with only a single satellite.

Each DSP satellite has a large, linear infrared-sensing array--roughly 6000 pixels long--which effectively rotates across the image of the earth once every 10 seconds,

1) SLBMs 2) how long needed to detect?

3) from
frontal view
attack?
(ICBM)
contribute
to prod.
of threat!

searching for the light given off by enemy missiles.

The United States has placed a high premium on this global coverage. As reported by the Washington, D.C.-based Federation of American Scientists, the main threat that the DSP satellites are charged with detecting is the launch of missiles from the Russian Federation. This fact can easily be determined by analyzing the positioning of the U.S. satellites: they have been, and continue to be, preferentially positioned over the Eurasian land mass, from which they can look down on all the Russian and Chinese ICBM fields.

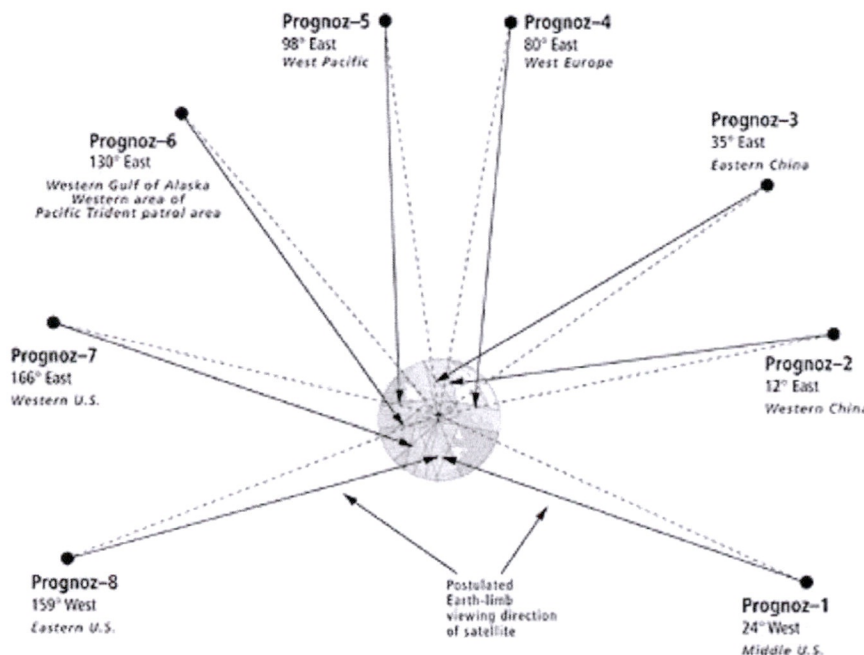


Fig.3. The Soviets reserved eight geostationary satellite slots for early-warning satellites with the International Telecommunication Union. These slots are perfect for viewing strategically significant regions--shown on the globe as yellow swaths--at grazing angles, against the black background of space. At present, only one of these satellites is active.

Why then has Russia also reserved slots for geostationary early-warning satellites over Eurasia? Our analysis indicates that each registered position would be ideal for viewing an important threat area on the earth's surface from a grazing geometry [Fig. 4].

Does that set-up mean that Russia's early-warning technology is incapable of looking down at the earth's surface and distinguishing missile plumes from natural backgrounds? Probably not. More likely it demonstrates a clever scheme for making maximum use of satellites that have a limited field of view of the earth. What is known is that the Soviet Union, and now Russia, could and can produce sizable arrays of infrared detectors. For instance, researchers in Russia have reported producing linear arrays of about 1000 pixels. Still, it is unclear if the quality of these arrays (their sensitivity and internal noise) meets the standard needed for space-based early-warning applications. Also not known is the extent to which Russian fabrication science and technology has been damaged by the economic collapse.

Russian early-warning satellites of the same basic design as those in the highly elliptical orbits described above have almost always been positioned above the Atlantic Ocean. From there, they can view the continental U.S. missile fields at a grazing angle. As Russia's highest-priority position for an operating satellite, it has been occupied nearly continuously since 1983.

A second geosynchronous satellite slot has been reserved at exactly the same ideal viewing angle, but on the other side of the United States. If these satellites were in fact designed for earth-edge viewing, the purpose of the slots is clear. Since the sun is close to the boresight of one or the other satellite during sunrise and sunset, the use of two guarantees that at least one of them is able to observe U.S. ICBM launches at any time of day.

Russian space experts have indicated that these second-generation geosynchronous satellites indeed are able to view just a small portion of the earth's surface. But how small? The size can be estimated by looking at how the Russian and U.S. satellites process their data. It is known that Russian early-warning satellites send essentially all of their raw data to the earth for processing.

In contrast, the U.S. DSP satellites process a good deal of their data onboard, to remove most of the slowly varying spatial part of the naturally occurring infrared background. As a result, only about one half of a percent of the collected infrared data is sent to earth over DSP's communication links, which have data rates of only 1 Mb/s.

Russian satellites transmit data to the ground at a rate about 15 times greater than that of a U.S. DSP. (If a U.S. DSP transmitted only raw data to the ground, it would have to send that data at a speed roughly 200 times higher than that quoted in public reports.) Knowing the data collection rates of the U.S. DSP and Russian satellites, and assuming that the Russian satellites perform no onboard data processing, the field of view of Russian early-warning satellites is perhaps 15 to 20 square degrees. While this can cover a substantial area of the earth's oceans, it is far from global coverage.

Clearly, even if Russia's geostationary early-warning satellites could look down on strategically important areas, vast stretches still exist where a missile could be launched without being detected. Russian experts have stated that their country's military doctrine for launch under attack requires that they detect a massive U.S. nuclear attack. If that statement is true, such limited coverage might be adequate. Some Western analysts, however, believe that the Russian doctrine calls for launch against a less-than-massive attack.

And if the two countries do enter into future arms-control agreements mandating deep reductions of deployed land-based nuclear missiles, more and more of the U.S. nuclear arsenal will be deployed at sea. If that happens, it will become even harder for Russia's semi-blind warning systems to verify that ambiguous events are in fact benign.

Options for assistance

Given the vulnerability of Russian nuclear forces relative to those of the United States, and the incomplete coverage of Russian warning systems, the danger of inadvertent nuclear war from a false alarm may be greater today than ever--and could increase further if current trends are not reversed.

What can be done to lessen that threat? One possible avenue is to assist Russia in closing the gaps in its space- and ground-based early-warning coverage. The Congressional Budget Office (CBO) published the first results of its analysis for assisting Russia in this area the day after Presidents Clinton and Yeltsin announced at their September 1998 summit in Moscow that the two countries would work together to decrease just this threat. In that

analysis, the budget office considered five options for lending assistance.

In one CBO option, the United States would supply Russia with data from U.S. early-warning satellites, much as it does with some of its allies today. DSP data sent to the early-warning center at Cheyenne Mountain in Colorado could be filtered, to obscure any vulnerabilities the DSP system might have, and then sent across a dedicated phone line to Moscow. This option would be quite quick to implement and relatively inexpensive, costing the United States roughly \$5 million dollars in the first five years. The drawback could be Russian unwillingness to put much faith in such data. Would Russian leaders really believe the United States would send them accurate information if it did launch a surprise attack?

Another option is for the Russians to accept the U.S. offer, made at the September 1998 summit, of setting up a joint early-warning center. In preliminary descriptions of the proposed center, a small group of U.S. officers, with displays of U.S. early-warning information, would occupy the same Moscow room with Russian officers, with displays of Russian early-warning information, and both staffs would be free to look over each others' shoulders to verify that neither early-warning system showed missile launches. Russia has been ambivalent about this idea at best. Still, both countries did implement a version of it over New Year's weekend to monitor Y2K problems [see "Mending nuclear fences"].

Since publishing its 1998 analysis, CBO has learned that Russia has seven early-warning satellites built but never launched--it either cannot afford to do so or is unwilling to devote the necessary resources. These satellites are intended for highly elliptical orbits that would observe the sky 24 hours a day above continental U.S. missile fields; they would not provide global coverage. CBO estimates that it would cost the United States approximately \$200 million to pay for the launch of these satellites.

Other options CBO analyzed consisted of various levels of financial and technical assistance, to help Russia improve its own system. For example, if the United States paid the salaries of the Russian scientists and engineers needed to design and fabricate a new satellite, it might cost \$60 million over five years. If the assistance included financing hardware and launch costs, putting three satellites in geostationary orbit might be as much as \$1.3 billion, using U.S. systems as an analogy for costing.

Of course, costs should be far less in Russia. Some Russian experts have estimated that a completely new geostationary system developed there might cost \$675 million--the rough equivalent of a year and a half of Nunn-Lugar funding, an ongoing U.S. aid program to help Russia shore up its nuclear weapons complex [see "Minding Russia's nuclear store"].

Another CBO suggestion involves continuing a joint research effort known as the Russian American Observation Satellites (Ramos) project. Ramos was first proposed in 1992 as a way to engage Russia in a cooperative missile defense program that would provide technical information to both sides' early-warning programs. But for reasons that are still unclear, Ramos was unilaterally canceled by the United States in March 1999.

If Ramos were to be revived and fully funded, with the United States putting up the total program cost of about \$250 million, it might greatly help Russia design its next generation of early-warning satellites. For instance, Ramos could study the use of polarized filters as a means of further reducing the natural backgrounds that can decrease the satellites'

sensitivity. This technique would work much like wearing sunglasses at the beach to cut glare from the ocean. Surprisingly, it has yet to be tried in an early-warning capacity.

Based on discussions with Russian early-warning experts, the authors believe there may be more options than those identified in the CBO report. One would place a system of video monitors at U.S. and Russian ICBM fields. This approach would be similar to a monitoring scheme that Sandia National Laboratories in the United States and the Kurchatov Institute in Moscow have been studying for monitoring each country's supply of nuclear weapons material. While this monitoring system promises to be inexpensive, it would be limited to land-based units and could not be easily adapted to submarine-launched missiles.

Another option would be for the United States to help in constructing two radars that would close the gaps in Russia's ground-based radar system. A northeast-looking radar could be built at existing radar installations at either Mischelevka or Komsomolsk on Amur to cover the corridor into the Pacific. To improve radar warning against an Atlantic attack, aid could be given to complete an existing, but not operating, radar at Baranavichi, Belarus.

Handwritten: 1983 (2000) ICBMs
 Currently, the U.S. Navy is in the process of replacing the Trident I C-4 missiles on its four most modern Pacific-based Trident submarines with Trident II D-5s. The respective conversions are scheduled to start in 2000, 2001, 2005, and 2006 and will take two years each. Since the Trident II is far larger and more accurate than the Trident I, these submarines will pose an ever greater threat to Russia and its central strategic nuclear forces. Not only will the Tridents have vastly greater firepower, but they will be able to launch attacks through the existing Pacific hole in Russia's ground-based radar system, with the potential to destroy even the most highly protected missiles in the hardest of underground missile silos. Yet another option that could greatly reduce the possibility of an accidental launch of Russian forces might be to simply not deploy these Trident IIs as currently planned. *Handwritten:* yes!

Outcome: mistrust

Despite expansive claims about U.S.-Russian early-warning cooperation made by President Clinton and other senior members of the Administration during and after the September 1998 summit, there have been few if any results of substance. The U.S. lack of initiative in this area has made many knowledgeable Russians suspicious of the true intent behind the proposed Joint Early Warning Center in Moscow. Their concern is that the United States intends to use the center to learn more about their country's weaknesses while doing little or nothing to help correct the perilous state of its early-warning systems.

The United States has also offered to finance the completion of an early-warning radar in Russia's far eastern areas, and to help with an early-warning radar in Azerbaijan. But both radars look south and therefore do not deal with the far more dangerous problem of the gaps in Russia's early-warning radar network.

Handwritten: !
 Given the increased tensions between the United States and Russia over the Kosovo War, NATO expansion, Chechnya, and the U.S. plan to build a national ballistic missile defense system--and factoring in the changing internal political situation in both Russia and the United States--it is sadly unclear what can be accomplished in the short term.

About the authors

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See also:

- Clinton Wants To Share Secrets With Putin, - in *Russian*, (by Sergei Guly, *Novyye Izvestia*, June 2, 2000, p.3)
- 'Blind Spots' Fuel Russian Fears of U.S. Shield, (by David Hoffman, *The Washington Post*, Thursday, June 1, 2000; Page A01)

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